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Geology of the unconsolidated deposits of Lake County, Indiana

Reuben J. Vig
University of North Dakota

GEOLOGY OF THE UNCONSOLIDATED DEPOSITS, OF LAKE COUNTY, INDIANA

by

Reuben J. Vig

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This thesis submitted by Reuben J. Vig in partial fulfillment of the requirements for the Degree of Master of Science in the University of North Dakota, is hereby approved by the Comittee under whom the work has been done.

Wilson M. Laird
Chairman

F. D. Holland Jr.

Mark Rich

Christopher J. Hamre
Dean of the Graduate School

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GEOLOGY OF THE UNCONSOLIDATED DEPOSITS, OF LAKE COUNTY, INDIANA

Reuben J. Vig

ABSTRACT

Lake County is in the extreme northwestern corner of Indiana. The county is divided into three physiographic units: (1) Calumet lake plain, (2) Valparaiso moraine, (3) Kankakee glaciofluvial plain.

The Calumet lake plain was covered by glacial Lake Chicago. Beach lines show the areal extent of the various phases of the lake's history. The Valparaiso moraine, a broad upland, trends east-west across the county. An end moraine on the north side of this upland is correlated with the Tinley moraine in Illinois. The Kankakee glaciofluvial plain, formerly marshland, slopes gently from the Valparaiso moraine to the Kankakee River.

The bedrock surface has a general slope toward the basin of Lake Michigan. Five former stream valleys enter the basin from a preglacial drainage divide in Illinois.

Till averaging about 50 feet in thickness, probably of Illinoian (?) age, lies above the bedrock surface. A sheet-like deposit of sand and gravel lies beneath the drift of the Valparaiso moraine and crops out on the surface of the

Kankakee glaciofluvial plain. Presumably, the sand and gravel was laid down during the retreat of the ice sheet that deposited the Illinoian (?) till. Two distinct tills were deposited upon this sand and gravel. The lower is a gray-blue clayey till, which is overlain by the upper buff to yellow, silty, clay till of the Valparaiso moraine.

Lake Michigan provides water for the northern third of the county and ground water is the source of supply for the rest of the county.

INTRODUCTION

Purpose and Scope

Lake County, because of the strategic importance of its location, has become one of the great industrial centers of the world. The principal cause for the development of this industrial center was Lake Michigan; a barrier to east-west land traffic. At the head of Lake Michigan the highly developed railroad, highway, and water-transportation systems intersect and come to a focus. The available water supply, suitable topography, and favorable conditions for expansion are important factors in the growth of the county. Greater growth of both industry and population is predicted for the county due to the completion of the Great Lakes-St. Lawrence Seaway.

An investigation of the ground-water resources of a ten-county area in northwestern Indiana was begun in June 1954 by personnel of the U.S. Geological Survey in cooperation with the Water Resources Division, Indiana Department of Conservation. Data used in this thesis was collected as part of this ten-county area investigation and also from other published reports.

The purpose of this thesis study was to map and describe the areal geology of Lake County. Special emphasis is placed upon the surface and subsurface geology of the unconsolidated deposits laid down during the Pleistocene. The geologic information is needed as an aid (1) in the proper development of the natural resources of the county, (2) in the sound planning of engineering works and land utilization, and (3) in the interpretation and description of the glacial deposits of Lake County.

Location of Area

Lake County is in the extreme northwestern corner of Indiana (fig. 1) and has an area of about 517 square miles. It has two natural boundaries, Lake Michigan on the north and the Kankakee River on the south. The west side adjoins the State of Illinois and on the east side is Porter County, Indiana.

Methods of Investigation

A geologic reconnaissance of Lake County was made by north-south and east-west traverses at approximately one mile intervals. Sites visited included sand and gravel pits, clay pits, road cuts, and sand dune areas. Geological features were examined, sections were measured in pits, and spot samples were taken for detailed study of the lithology.

Observation wells were established to obtain data concerning the changes in storage of the ground-water aquifers and to determine the factors affecting the changes in the water level. A quality of water program was started to obtain information on the chemical quality of water from the various aquifers.

Well drillers were interviewed regarding the character

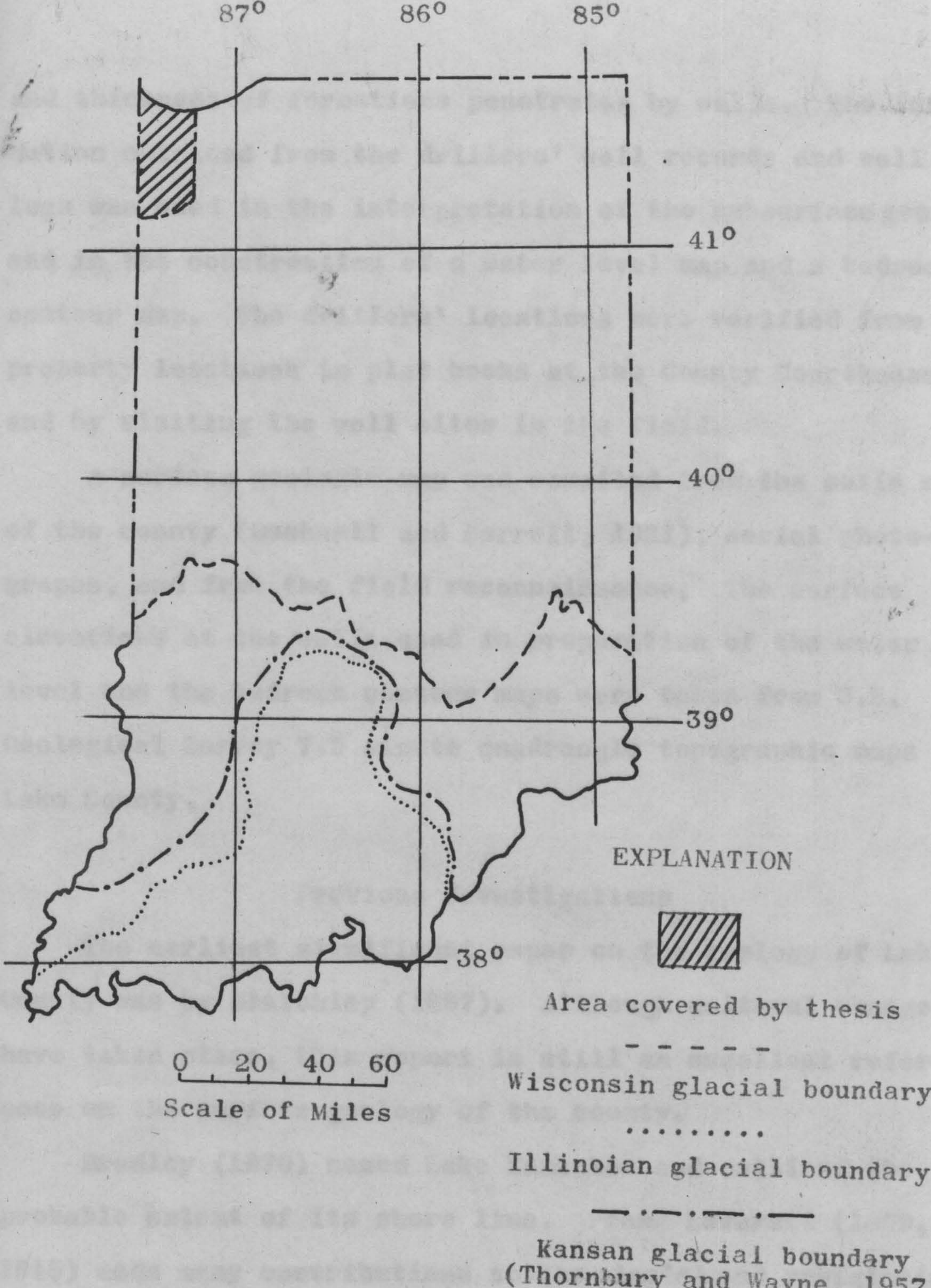

Figure 1.--Diagrammatic map of Indiana showing Lake County and glacial boundaries.

and thickness of formations penetrated by wells. The information obtained from the drillers' well records and well logs was used in the interpretation of the subsurface geology and in the construction of a water level map and a bedrock contour map. The drillers' locations were verified from property locations in plat books at the County Courthouse and by visiting the well sites in the field.

A surface geologic map was compiled from the soils map of the county (Bushnell and Barrell, 1921), aerial photographs, and from the field reconnaissance. The surface elevations at the wells used in preparation of the water level and the bedrock contour maps were taken from U.S. Geological Survey 7.5 minute quadrangle topographic maps of Lake County.

Previous Investigations

The earliest significant paper on the geology of Lake County was by Blatchley (1897). Although cultural changes have taken place, this report is still an excellent reference on the surface geology of the county.

Bradley (1870) named Lake Kankakee and outlined the probable extent of its shore line. Frank Leverett (1899, 1915) made many contributions to the glacial and postglacial history of the north central states. Although previously mentioned in publications by Blatchley (1897) and Leverett (1899, 1915), reports on the dunes of northwest Indiana were written by Barrett (1916), Cressey (1928), and Bieber and Smith (1952).

Many reports have been written on the history and formation of the Great Lakes and of Lake Chicago. Those by Bretz (1951, 1955) and Hough (1958) give new theories concerning the events that occurred during the history of the Great Lakes.

Acknowledgments

The writer expresses his appreciation to Dr. Wilson M. Laird, Chairman of the Department of Geology, University of North Dakota for his general supervision and counsel. Acknowledgments are also made to Dr. F. D. Holland, Jr., and Dr. Mark Rich of the Geology Department of the University of North Dakota for their suggestions and review of the report. The writer expresses his appreciation to the U.S. Geological Survey, Ground Water Branch, Indianapolis, Indiana, and the Water Resources Division of the Indiana Department of Conservation for their cooperation in obtaining open-file data and published reports used in the thesis. Acknowledgments are made to members of the office staff of the Ground Water Branch, Indianapolis, Indiana, especially Claude M. Roberts, District Geologist and J. S. Rosenshein, Project Chief, for their review, suggestions, and contributions to the thesis. Special thanks are due many well drillers for their cooperation in supplying well data.

Appreciation is given to Elmira Vig for her assistance in preparing the plates and typing the report.

GEOGRAPHY

Physiography and Topography

Lake County is near the geographic center of the Eastern Lake Section of the Central Lowland province (Fenneman, 1938). This province is part of the great Interior Plains, a major physiographic division of the United States that extends from the Applachian Mountains westward to the Rocky Mountains.

Malott's (1922) physiographic classification of Indiana places Lake County in the "Northern Moraine and Lake Region". This region is subdivided into five units and includes all the glaciated area north of the Wabash River. Three of Malott's subdivisions, the Calumet lacustrine plain, the Valparaiso moraine, and the Kankakee lacustrine plain occupy parts of Lake County.

Lake sediments are not extensive in the county and were deposited in a small area near Hobart. The Kankakee plain is composed mainly of glaciofluvial sand and gravel. Therefore, Malott's Calumet lacustrine plain and the Kankakee lacustrine plain are called, in this paper, the Calumet lake plain and the Kankakee glaciofluvial plain, respectively.

The northern region, or Calumet lake plain which was covered by glacial Lake Chicago, extends about 14 miles south of Lake Michigan on the west side of the county and narrows to nine miles at the Porter County line. The land surface of the lake plain slopes toward Lake Michigan and ranges in elevation from about 580 feet, the approximate mean lake level of Lake Michigan to about 640 feet above mean sea level at the edge of the Valparaiso moraine. The gently rolling surface has ancient beach lines that show the phases of former glacial Lake Chicago. The maximum local relief of the Calumet lake plain is in the northeastern part of the county near Miller's Beach where sand dunes, the result of wind action, rise more than 150 feet above Lake Michigan.

The central region or Valparaiso moraine covers nearly half of the county. This moraine, which trends east-west across the county, is about 14 miles wide on the east and about 18 miles wide near the Illinois boundary. The moraine has a more rugged surface than either the Calumet or Kankakee plains, although a large portion of the moraine is relatively flat to undulating.

The highest elevation in the county is within the moraine region northeast of Palmer near the Porter County line. (See plate 1.) The moraine here has an elevation of about 790 feet above mean sea level, which is about 210 feet above the mean level of Lake Michigan.

The southern region or Kankakee glaciofluvial plain occupies a strip approximately five miles wide between the Valparaiso moraine and the Kankakee River. The slope of the land surface is southward off the southern edge of the moraine and toward the Kankakee River. Except for a few sand ridges the southern region has little relief and elevations range from about 630 to 650 feet above mean sea level.

Drainage

The crest of the Valparaiso moraine is the divide which separates the natural drainage of the streams that flow toward the North Atlantic from those that flow toward the Gulf of Mexico. The divide across the county is developed entirely on glacial deposits of late Pleistocene age.

The land surface north of the divide is drained by the Little Calumet and the Grand Calumet Rivers. Originally these two streams were called the Calumet River, as there was no differentiation into two rivers until a channel was dug between the lake shore at South Chicago to Calumet Lake. This channel became the outlet for the two streams, as the flow of the lower portion of the former Calumet River (Grand Calumet River) was reversed. This reversal was possible only because of the very low gradient of the stream. The Little Calumet River is the upper portion of the original Calumet River.

Construction of the Sag Canal across the Continental Divide diverted the drainage of the Little Calumet River from the St. Lawrence to the Mississippi drainage basin. Burns Ditch near the boundary line between Lake and Porter Counties was dug to allow the excess flow of the upper reaches of the Little Calumet River to discharge directly into Lake Michigan. This makes the Little Calumet River unique as its water can be diverted into either of two major drainage basins.

The two main tributaries of the Little Calumet River are Turkey Creek and Deep River. The headwaters of these two streams are less than half a mile apart, being separated by a morainal ridge two miles east of St. John. Turkey Creek flows down the north slope of the moraine onto the Calumet lake plain and then turns eastward and flows between the sand ridges, located on the north, and the Valparaiso moraine on the south until it joins Deep River near Hobart.

The main tributary of the Little Calumet River is Deep River which collects the drainage of its branches and dredged ditches from St. John to Palmer. Deep River has many right angle bends in its course; a pattern that is controlled by the irregular deposits of glacial drift. The stream flowing down the natural gradient of the land surface, is forced to change direction and flow around these drift deposits. One of the more conspicuous right angle bends is at the Porter County line near Deep River. Here the stream turns abruptly north, having cut a valley since postglacial time 30 to 40 feet deep through a sag in the morainal ridge.

The Kankakee River receives no direct drainage off the south slope of the divide within the boundary of Lake County, as levees have been constructed along the river to prevent flooding. Singleton Ditch collects water from the streams flowing off the moraine and also drains water from the reclaimed swamp land. This ditch connects with Eagle Creek near Range Line and extends southwest across the southern part of Lake County into Illinois where it empties into the Kankakee River above Momence.

Spring Run, Cedar, Eagle, and West Creeks drain the south slope of the moraine and occupy valleys that were once drainageways for melt water pouring off the front of an ice sheet. The valleys are relatively short and straight and the melt water from the ice front traveled only a short distance before emptying into a lake (Leverett, 1915) in the Kankakee drainage basin.

Climate

The climate of Lake County, classified according to Thornthwaite (1948, p. 87), is humid, first mesothermal, no season of water deficiency, and a temperature-efficiency regime normal to second mesothermal.

Average annual air temperature is about 51°F. The growing season is usually 170 days in the northern part of the county and 160 days in the southern part (Visher, 1944, p. 122).

Average annual precipitation is 33 inches. Although the precipitation is fairly well distributed throughout the year, the winter months are somewhat drier. Table 1 gives the average monthly precipitation and temperature at the weather station in Gary, Indiana.

Table 1.--Average monthly precipitation and temperature at Gary, Indiana, 1936-1959 (1/).

Month	Average precipitation (inches)	Average temperature (°F)
January---	1.90	25.0
February--	1.40	28.0
March-----	2.60	37.0
April-----	3.00	48.0
May-------	3.50	59.0
June------	3.60	69.0
July------	2.80	75.0
August----	3.40	73.0
September-	3.50	67.0
October---	3.10	55.0
November--	2.60	41.0
December--	1.90	29.0
Annual----	33.30	50.5

1/ Data from U.S. Weather Bureau.

Economy Related to Surface Features

The economy of the county is related to its strategic location and the general flatness of the area. East-west land traffic is compelled by Lake Michigan to converge toward the Calumet lake plain. Also, the Great Lakes water-transportation system focuses on this area. Many large industries have located in Hammond, East Chicago, Whiting, and Gary.

Ninety-one percent of the population in Lake County is concentrated in this industrial area on the Calumet lake plain. Table 2 shows the areal distribution of the population with respect to the three physiographic divisions of the county.

The relatively flat top of the Valparaiso moraine and the plane-like surface of the Kankakee region are suitable for farming. The agriculture products from these two regions have a ready market in the Calumet and Chicago areas. The major crop and livestock production are shown in tables 3 and 4.

Water is an important natural resource of great economic value to Lake County. Lake Michigan is the chief source of water supply for the municipalities and industries of the Calumet lake plain and ground water is the source of water supply for the Valparaiso and Kankakee regions. Other natural resources of economic value include: (1) sand, used for road construction and many other purposes; (2) clay, used in the manufacturing of clay products; and (3) peat, used as a fertilizer.

Table 2.--Population and its distribution with respect to the physiographic divisions of Lake County, Indiana 1/.

Physiographic divisions	Population 1960	Percent of population	Approximate area (in sq. miles)	Percent of area	Population (per sq. mile)
Calumet lake plain--------	469,286	91	170	33	2,761
Valparaiso moraine------	38,480	8	252	49	153
Kankakee glacio-fluvial plain--------	5,504	1	95	18	58

1/ U.S. Census of population, U.S. Department of Commerce, Bureau of Census, Indiana, 1960.

Table 3.--Crop production in Lake County, Indiana, 1959 and 1954 1/.

Products	Acreage 1959	Bushels harvested	Acreage 1954	Bushels harvested
Corn--------	68,548	4,391,760	61,595	3,536,141
Wheat-------	11,411	357,311	11,579	372,180
Oats--------	12,343	530,596	21,163	750,314
Soybeans----	33,958	876,516	25,295	672,211
Potatoes----	110	25,789	89	21,356
Vegetables-	2,630	-	2,990	-

1/ Data from U.S. Census of Agriculture, 1959.

Table 4.--Livestock production in Lake County, Indiana, 1959 and 1954 1/.

Products	No. raised 1959	No. raised 1954
Cattle----	20,387	24,532
Hogs------	22,499	20,669
Sheep-----	3,315	2,986
Chickens-	104,370	151,158
Turkeys---	22,225	28,451

1/ Data from U.S. Census of Agriculture, 1959.

GEOLOGY

Geologic Setting

Lake County is in the central stable region of the United States (Eardley, 1951, p. 26). This area has a basement complex of crystalline rocks of Precambrian age that is overlain by sedimentary rocks. The depth of Precambrian rocks in Lake County is estimated to be about 3,500 feet below sea level (Henderson and Zietz, 1958, p. 28).

Sedimentary rocks of Devonian, Silurian, Ordovician, and Cambrian ages were deposited in Lake County during the Paleozoic Era. The Mt. Simon Sandstone of Cambrian age is the oldest formation encountered by drilling. A well was drilled at Crown Point to a depth of 3,100 feet below land surface (Blatchley, 1897, p. 44). The data from the well log is interpreted by the writer to have penetrated into the Mt. Simon Sandstone, based on data presented by (Gutstadt (1958, p. 19-25).

Apparently during the Cambrian and Ordovician Periods no earth movement of significance occurred in the central stable region. The Illinois and Michigan basins were originally a continuous structure (Eardley, 1951, p. 29) which probably had its origin in the Ordovician but the structure was not strongly expressed. An uplift area originating in the Silurian (Freeman, 1951) divided the structure into two parts. The uplift is known as the Kankakee arch (Ekblaw, 1938, p. 1426) and is apparently related to the northwest prong of the Cincinnati dome, and to the southeastward-trending arm of the Wisconsin arch. The Kankakee arch that underlies the southern part of Lake County acquired its structural relief by greater subsidence of the basins on its sides rather than by actual uplift (Eardley, 1951, p. 36).

The bedrock surface beneath the glacial deposits consists mainly of dolomite or dolomitic limestone of Silurian age. The youngest Paleozoic rocks in the county are the scattered erosional remnants of Devonian shale. According to well records and the cross sections of plates 5, 6, and 7 the Devonian shale lies above the Silurian rocks in the center of the county in the vicinity of Crown Point and in the extreme southern part near Shelby (fig. 2). These deposits indicate that sediments of Devonian and probably sediments of post-Devonian age were deposited over the area. Erosion has removed any sediments that may have been deposited between the Devonian and Pleistocene time.

In late Cenozoic time continental glaciers advanced from Canada, overriding the eroded bedrock surface and leaving widespread glacial deposits. The ice sheets spread over the northern part of the United States and covered all but the southern part of Indiana (fig. 1).

Four independent stages of glaciation are recognized in North America. They are, from oldest to youngest, Nebraskan, Kansan, Illinoian, and Wisconsinan. The glacial stages were separated by interglacial stages, during which

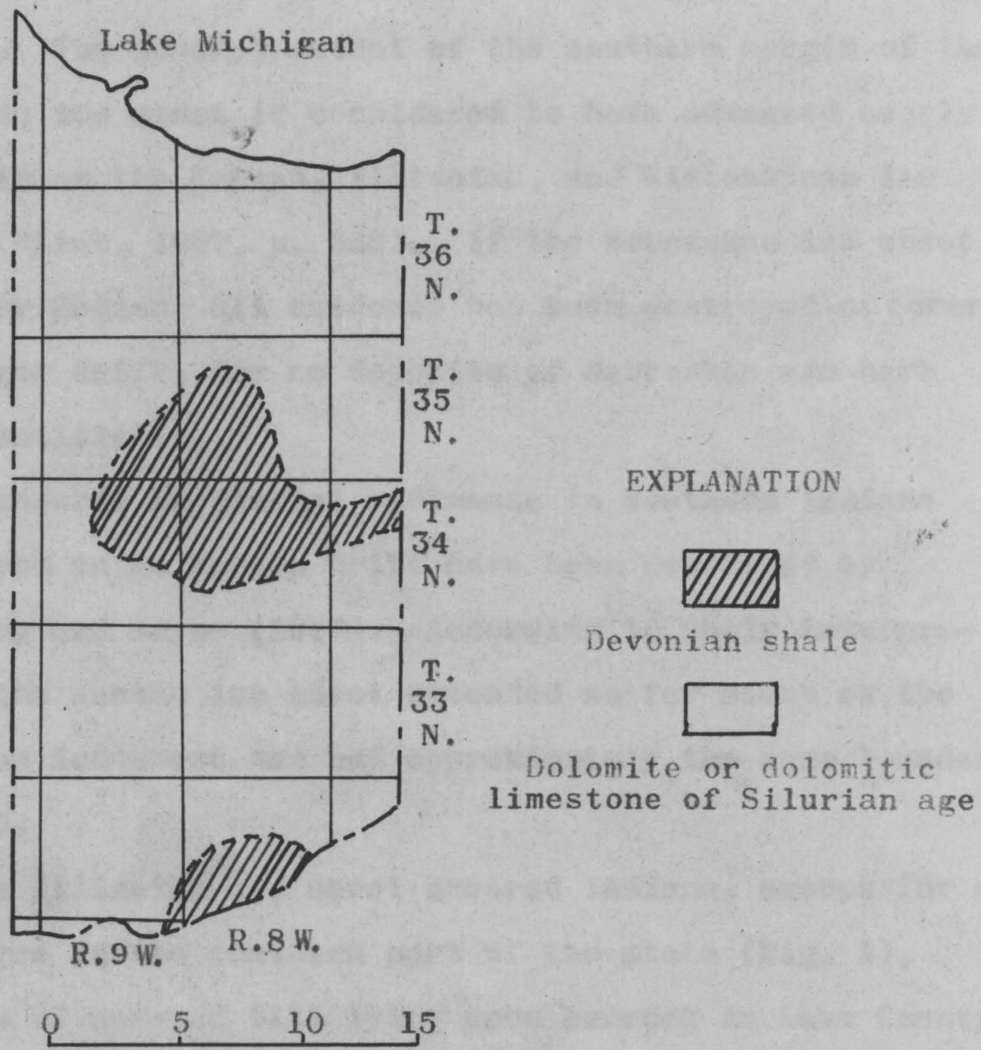

Figure 2.--Diagrammatic bedrock surface map of Lake County, Indiana.

the climate was probably as temperate as it is at present.

There is no evidence of the Nebraskan glaciation in Indiana. The general extent of the southern margin of the Nebraskan ice sheet is considered to have advanced nearly as far south as the Kansan, Illinoian, and Wisconsinan ice sheets (Flint, 1957, p. 338). If the Nebraskan ice sheet did enter Indiana all evidence has been destroyed or covered by younger drift, for no deposits of Nebraskan age have been identified.

Exposures of glacial sediments in southern Indiana considered to be Kansan drift have been described by Thornbury and Wayne (1957). According to their interpretation the Kansan ice sheet extended as far south as the Illinoian ice sheet and had approximately the same boundary (fig. 1).

The Illinoian ice sheet covered Indiana, except for a small area in the southern part of the state (fig. 1). Deposits of undated till lying upon bedrock in Lake County maybe of that age. Drift deposits, as much as 150 feet in thickness, separates this older till from the younger Valparaiso till of Wisconsinan age. This older, gray-blue, clayey till which overlies the bedrock is exposed in two pits north of Highland. No evidence of decomposed till was found to indicate a prolonged interval of weathering. Evidently, the upper weathered surface was removed by latter glaciation or eroded by the water (wave action) of glacial

Lake Chicago.

Sand and gravel underlying the Valparaiso moraine extends southward away from the moraine and crops out on the Kankakee glaciofluvial plain. This outwash probably was laid down during the retreat of the ice sheet that deposited the clayey till upon the bedrock. Therefore, the sand and gravel is probably Illinoian (?) in age.

A revised classification of the former Wisconsin glaciation is used in this thesis (fig. 3). The revised time-stratigraphic classification of the Wisconsinan Stage of the Lake Michigan lobe as used by the Illinois State Geological Survey is based on new data from radiocarbon dates (Frye and Willman, 1960, p. 2).

The Wisconsinan glaciation was the fourth and last major ice sheet advance into the central part of the United States. The history of the substages of this ice sheet is more readily reconstructed because of the excellent preservation of their deposits.

The Valparaiso moraine, a broad upland, encircling the south end of Lake Michigan trends east-west across the central part of Lake County. This moraine has been traced northwestward into Illinois and northeastward into Michigan. The glacier which deposited the Valparaiso moraine retreated an unknown distance and then the ice readvanced, encroaching upon the Valparaiso moraine. The end moraine left by the readvance of the ice is herein called the Tinley moraine.

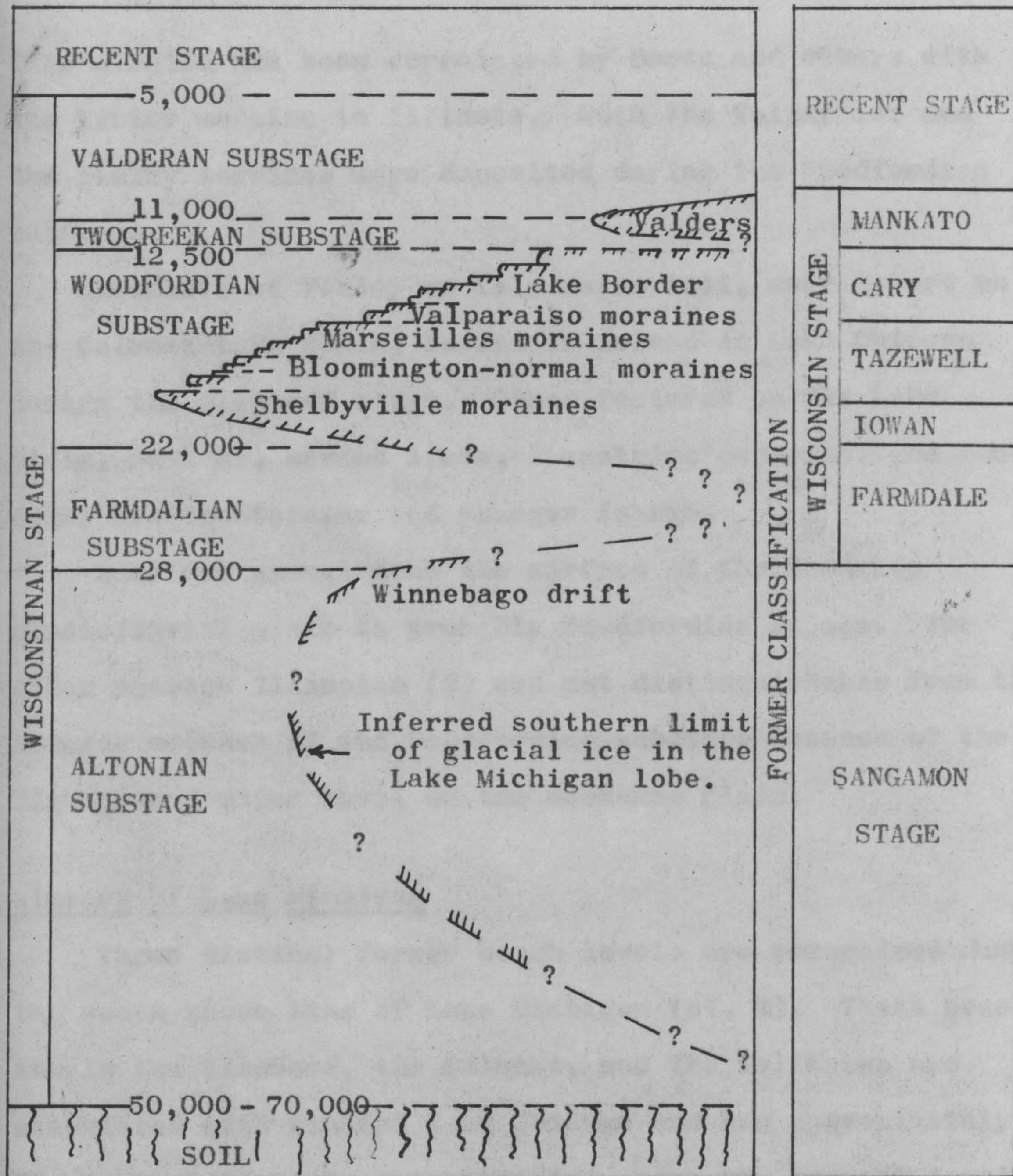

Figure 3.--Time-stratigraphic subdivision of the Wisconsinan Stage in the Lake Michigan glacial lobe. Only part of the named moraines in Illinois are shown, and named moraines are morphostratigraphic units. The inferred limit of glacial ice through time is shown diagrammatically on a vertical scale in radiocarbon years. After Frye and Willman (1960, fig. 1).

This moraine has been correlated by Bretz and others with the Tinley moraine in Illinois. Both the Valparaiso and the Tinley moraines were deposited during the Woodfordian substage.

Remnants of Tinley or Valparaiso till, near Hobart on the Calumet lake plain, formed an island in Lake Chicago during the Glenwood stage. Other features on the Lake plain, such as, strand lines, lacustrine deposits, and sand dunes are Woodfordian and younger in age.

Sand and gravel near the surface of the Kankakee glaciofluvial plain is probably Woodfordian in age. The older outwash Illinoian (?) was not distinguishable from the younger outwash of the Woodfordian substage because of the high ground-water level on the Kankakee plain.

History of Lake Michigan

Three distinct former beach levels are recognized along the south shore line of Lake Michigan (pl. 2). These beach levels the Glenwood, the Calumet, and the Tolleston are associated with glacial Lake Chicago and are approximately 55, 40, and 20 feet, respectively, above the present level of Lake Michigan.

The early geologists stated that Lake Michigan attained its present level by a series of steplike lowerings. Lowering to the Tolleston level was generally considered to have been caused by lake water overflowing the morainic dam, a low segment in the Valparaiso moraine, in the vicinity of the already-existing Sag and DesPlaines Valleys. According to this theory, drainage toward the Mississippi River ceased when the level of the former lake reached the Tolleston beach level as bedrock in the Chicago outlet prevented further down-cutting. The retreating ice uncovered a new outlet to the north with drainage into the St. Lawrence basin and lowering continued to the present level of Lake Michigan.

Later investigations have shown in the discovery of buried peat beds and a buried soil profile (Bretz, 1951; Zumberge and Potzer, 1956), that low-water phases occurred during the history of glacial Lake Chicago. This new evidence has required some revision of the former interpretation of the history of the Great Lakes.

As the ice receded northward into the Lake Michigan basin, during the Woodfordian substage, glacial Lake Chicago was formed between the ice front to the north and the Valparaiso moraine to the south. The lake water discharged across the morainic dam in the vicinity of the Sag and DesPlaines Valleys to enter the Mississippi drainage. The Glenwood and Calumet phases correspond to stillstands of glacial Lake Chicago produced by resistant boulder pavements in the outlet channels. Bedrock rather than boulder pavement prevented further down-cutting during the Tolleston phase (Bretz, 1955, p. 109).

Glacial advances during the Glenwood and Calumet phases blocked outlets to the east and increased the discharge from glacial lakes in Ontario, southeastern Michigan, and western Ohio into glacial Lake Chicago. The greatly increased volume of water caused the removal of the boulder pavements, deepened the discharge outlets and lowered the level of glacial Lake Chicago. The two episodes of channel deepening lowered the lake about 20 feet each time. Bedrock in the Chicago outlet prevented further down-cutting and established the level for the Tolleston stage. Retreat of the ice to the north uncovered lower outlets which resulted in further lowering of glacial Lake Chicago.

At least twice during the history of glacial Lake Chicago the ice front receded far enough to the north to open the Mohawk and Hudson outlets to the east. The discharge through these newer outlets lowered the lake level below discharge levels of the southwestern outlet of the Sag and DesPlaines Valleys (Bretz, 1955, p. 114). An extremely low water level in the Lake Michigan basin, known as the Lake Chippewa phase, estimated to be 350 feet below the present Lake Michigan level, resulted (Hough, 1958, p. 238).

With the disappearance of the Wisconsin ice sheet from the Great Lakes region, rebound through crustal upwarping raised the elevation of Lake Michigan's outlet to the St. Lawrence drainageway (Hough, 1958, p. 135). The present level of Lake Michigan is considerably higher than the low level of the Lake Chippewa stage because of this crustal upwarping.

Bedrock Topography

The general configuration of the bedrock surface underlying Lake County is shown in plate 3. The contours on the bedrock surface were compiled from more than 250 records of wells penetrating bedrock and from 31 seismic determinations (See plate 4). The depth to bedrock can be estimated by subtracting the value of the bedrock surface contour (pl. 3) from the value of the land-surface contour (pl. 1).

The general slope of the bedrock surface is toward the Lake Michigan basin. In the southern part of the county the bedrock surface is nearly flat and has a gradual slope to the east and southeast (pl. 3). The highest point on the bedrock surface is more than 625 feet above mean sea level in the southwestern part of the county and is the only place where the bedrock surface rises above the mean level of Lake Michigan (580 feet). The bedrock topography of the western part of the county is more rugged than in the eastern part and rises in elevation from about 450 feet near Lake Michigan to about 625 feet near the Kankakee River.

A preglacial drainage divide that separated the ancient Mississippi River from the St. Lawrence drainageway to the east is located in Illinois a few miles west of Lake County

(Horberg, 1950, p. 44). The divide trends north-south and probably crosses the southwestern corner of Lake County. Five preglacial stream valleys (fig. 4) entered the county from Illinois. Their source was near the crest of the divide. All these stream valleys are at elevations less than 450 feet above mean sea level in the vicinity of the present Lake Michigan.

The bedrock map shows a valley entering Lake County in the SW¼ sec. 36, T. 37 N., R. 10 W. This valley is a continuation of the buried Hadley Valley in Illinois (Horberg, 1950, p. 44; Suter and others, 1959, p. 21). In preglacial time the stream in Hadley Valley flowed toward the Lake Michigan basin. Horberg (1950, p. 44) reported that prior to Illinoian time the flow was reversed and also suggested the existence of an ancestral Lake Chicago. The discharge from this lake apparently breached the bedrock divide and cut a deep trench more than 50 feet below the Chicago outlet.

Near Dyer, Indiana a buried valley trends northeast and probably joins Hadley Valley north of the present shore of Lake Michigan. The streams of these two valleys had low gradients and flowed on rocks of Silurian age.

The remaining three bedrock valleys converge near Cook, Indiana to form the longest preglacial valley in the county. The valley has a general north to northeast trend and enters the Lake Michigan basin about two miles west of Porter County. This valley may connect with the preglacial valley

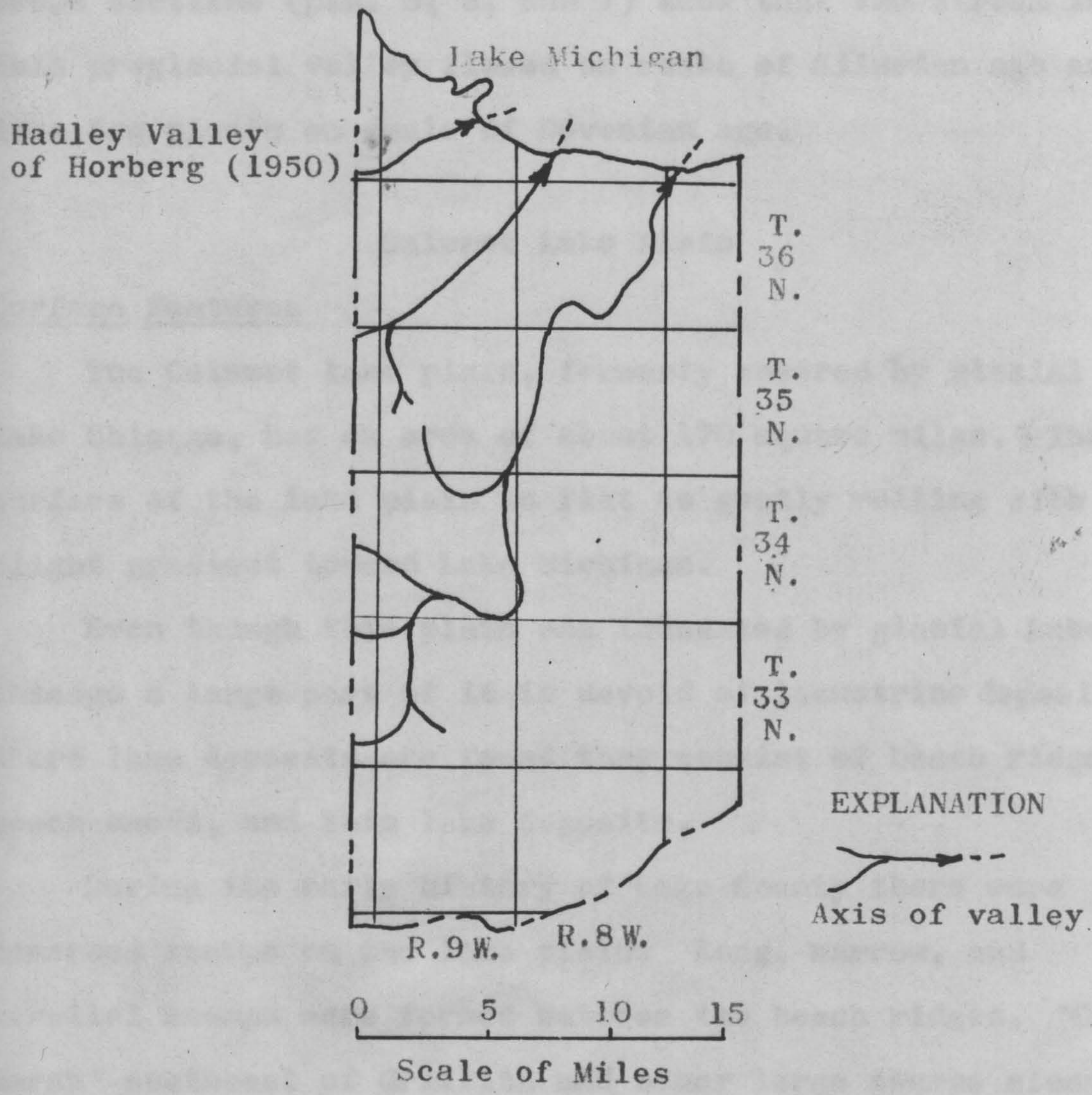

Figure 4.--Diagrammatic map of Lake County, Indiana, showing bedrock valleys.

in Porter County described by Wayne (1956, p. 34). The cross sections (pls. 5, 6, and 7) show that the stream in this preglacial valley flowed on rocks of Silurian age and in a few places on shale of Devonian age.

Calumet Lake Plain

Surface Features

The Calumet lake plain, formerly covered by glacial Lake Chicago, has an area of about 170 square miles. The surface of the lake plain is flat to gently rolling with a slight gradient toward Lake Michigan.

Even though this plain was inundated by glacial Lake Chicago a large part of it is devoid of lacustrine deposits. Where lake deposits are found they consist of beach ridges, beach sands, and thin lake deposits.

During the early history of Lake County there were numerous swamps on the lake plain. Long, narrow, and parallel swamps were formed between the beach ridges. "Cady Marsh" southeast of Griffith and other large swamps along the Little Calumet River are shown on the soils map of Lake County (Bushnell and Barrell, 1921). Many of these swamps have been drained or filled.

Prior to man's occupancy the south shore line of Lake Michigan was a smooth curve. Reclamation of marshland for industrial expansion and dumping of industrial waste products and other fill material behind bulkheads extending out into

Lake Michigan has changed the shore line in many places (pl. 2). At Whiting, on the lake front, a bluff having the appearance of rock is composed of waste slag from the steel mills.

Beaches of Lake Chicago.--The most conspicuous deposits left by glacial Lake Chicago are the beach ridges that stretch for miles across the lake plain. Sand beach deposits were built on land at the waters edge by wave action, or as bars somewhat offshore at the line of breakers. The relative elevation of some of the beach ridges is increased by dunes of wind-blown sand.

The highest beach of glacial Lake Chicago is called Glenwood beach, the name given to a similar feature at Glenwood, Illinois (Leverett, 1915, p. 350). This beach passes through Dyer and continues eastward across the county (pl. 2). Glenwood beach is discernible between Dyer and Schererville, but east of Schererville the beach is indistinct because of the many embayments along the Valparaiso moraine.

Remnants of the Tinley or the Valparaiso till near Hobart formed an island in Lake Chicago during the Glenwood stage (pl. 2). From this island a spit formed that extended to Griffith. Deposition of material transported by longshore currents was built up into sand ridges by wave action to form the spit. The north side of the spit is a simple curve, but the south side has three successive "fingers", ridges of sand projecting southward. Storm waves tended to swing the end of the spit to the south but the addition of debris shoaled the water and the growing spit fingers were abandoned and new ones were built. Gravel pits in sec. 36, T. 36 N., R. 9 W. and sec. 31, T. 36 N., R. 8 W. show that the spit consists of stratified sand with pebbles dispersed throughout.

Calumet beach parallels the Little Calumet River in the county from Munster eastward to Porter County (pl. 2). This shore line is well defined and capping sand dunes have made the beach ridge more prominent. Highways U.S. 6 and U.S. 41 (Ridge road) follows the crest of the Calumet beach. According to Hough (1958, p. 182), the lake stage producing this ridge had only a relatively brief existence.

The lowest of the three prominent beaches of glacial Lake Chicago is named Tolleston beach. The name is taken from an early settlement which is now part of Gary (Leverett, 1915, p. 356). The beach enters the state from the west on the south side of Hammond and trends eastward about midway between the Little Calumet and Grand Calumet Rivers (pl. 2).

West of Gary the lake plain is characterized by long, narrow, parallel, sandy beaches indicating successive lowering of the lake. Between the Tolleston beach ridge and Lake Michigan, 79 of these long, parallel, sand ridges have been counted on aerial photographs (Bieber and Smith, 1952, p. 10). The Tolleston beach ridge and the sand ridges to the north are being destroyed by industrial and urban land developments.

Sand was derived from weathered glacial drift, sandstone, and other quartz-bearing rocks. The bluffs (glacial drift) was undermined and the material was sorted by wave action along both the eastern and western shores of Lake Michigan. Sand derived from the glacial drift, and sand brought in by streams and rivers was transported to the head of Lake Michigan by longshore currents from both sides of the lake.

Erosion of the bluffs and deposition of sand along the lake shore has continued for thousands of years and is still actively going on. Leverett (1899, p. 282) stated that a strip 150 feet in width between Waukegan and Evanston, Illinois was undermined and carried into the lake during the thirty years from 1860 to 1890.

The beach sands are well sorted and over 90 percent of the grains are classified as medium to fine sand (Pettijohn, 1949, p. 233; Bieber and Smith, 1952, p. 17). The sands increase in coarseness westward into Illinois and eastward toward Michigan. The change in grain size is probably related to the distance from the source and to the longshore currents which carry the sand southward to Lake County at the head of the lake.

Cressey (1928, p. 31) stated that quartz grains constitute more than 90 percent of the beach and dune sands.

Other lightweight minerals are principally feldspars. Carbonate minerals amount to little more than a trace. The heavier minerals (specific gravity more than 2.95) are amphibole, pyroxene, illmenite, magnetite, epidote and garnet (Pettijohn, 1931, p. 438). Refuse, especially slag, is being added to the beach sands from steel and other industries located along the shore of Lake Michigan.

Dunes.--Another striking feature of the Calumet lake plain is the sand dunes in the northeast corner of the county. A dune belt extends from Gary in Lake County to Michigan City in LaPorte County. The highest dunes in the county are southeast of Miller and are about 150 feet above the mean level of Lake Michigan. West of Gary smaller dunes were formed and in places wind-blown sands have capped some of the beach ridges.

The dunes were formed by winds, blowing across areas of sand that had been deposited along the shore. Since the dominant winds are from the southwest and northwest, the dunes are best developed on the southeastern shore of Lake Michigan. Vegetation has stablized most of the dunes.

The composition and grain size of the dune sand does not vary greatly from the beach sand, from which it is derived. The heavy mineral content of the dunes is slightly less than that of the beach sand. The lighter weight amphibole, pyroxene, and epidote predominate over such minerals as illmenite, magnetite and garnet (Bieber and

Smith, 1952, p. 19).

The sand dunes began as a series of fore-dune ridges which probably did not migrate far inland after their formation. Cressey (1928, p. 48) reported that the complex of dunes is not related to the present shore of Lake Michigan, but was formed by widening of the beach and the formation of successive fore-dune ridges. The widening of the beach was caused by deposition of sand carried by longshore currents, shoaling of the water, and extending the shoreline to the north.

In the NE¼NE¼ sec. 7, T. 36 N., R. 7 W. there is a sand dune with an exposed face of more than 50 feet. A nonconformable contact clearly shows that recent wind-blown sand is deposited over an older dune sand. The slope of eolian cross-bedding varies in direction and dip. The angle of dip on the windward side is usually lower than on the leeward side, where maximum dips as much as 35 degress occur. The bedding is indistinct in a newly cut face, but very distinct in the older wind-eroded face. The fact that the individual layers vary in grain size accounts for separation into beds. The coarser sand is white to light buff. Usually the beds containing the smaller grains are a darker buff and the sand is slightly indurated by cementation. The cementing substances are calcium carbonate, iron oxide and contained clay particles.

Subsurface Deposits

The unconsolidated deposits of the Calumet lake plain consist of sand and gravel that ranges in thickness from a thin veneer at the north edge of the Valparaiso moraine to more than 30 feet near Lake Michigan. This sand and gravel overlies a gray-blue clayey till that averages more than 50 feet in thickness.

In the SW¼NW¼ sec. 31, T. 36 N., R. 9 W. about 14 feet of till is exposed. In the lower 8 feet a gray-blue till contains many shale pebbles of Devonian age derived locally from the blue-black shale of the Lake Michigan basin. The upper 6 feet consist of 5 feet of yellow, silty, clay till overlain by 1 foot of weathered, silty, clay soil. The yellow, silty, clay till is Tinley or Valparaiso ground moraine overlying the gray-blue till of pre-Wisconsinan age. There is no indication of a weathered zone separating the two tills.

North of Highland on the Calumet lake plain in the NE¼ SW¼ sec. 16, T. 36 N., R. 9 W. about 55 feet of till is exposed. Till in this pit is considered by the writer to be pre-Wisconsinan, Illinoian (?) in age. The till lies upon bedrock and extends southward beneath the Valparaiso moraine (pl. 5). The younger Valparaiso till of Woodfordian age is separated from the older Illinoian (?) till, which lies on bedrock, by glacial drift which is more than 150 feet thick in places.

A silt about 3.6 feet thick separates the two till deposits, indicating two ice advances in this exposure. The upper part of the silt is finely bedded or laminated and appears to be cross-bedded in places which would indicate moving water. Bedding is absent in the lower part of this silt. The silt contains no pebbles.

Two feet of weathered, buff, silty soil is at the top of the pit. Below the soil zone is 30.6 feet of till. This till has a gray-blue color when wet, and becomes gray, hard and compact when dry. The till contains pebbles and lots of shale fragments. Beneath this till is the silt zone, 3.6 feet in thickness. Below the silt is 20.4 feet of till. This till is similar to the till above the silt, except, that it contains fewer pebbles and shale fragments. No cobbles or boulders were observed in the pit, although some maybe covered by 15 feet of water at the base of the pit.

Near the Little Calumet River northeast of Highland in the NE¼ sec. 22, T. 36 N., R. 9 W. about 15 feet of material is exposed. Pelecypods and gastropods are found in the upper 2.8 feet of material. The writer considers the shells to be from an early phase of the Calumet River's history rather than from that of glacial Lake Chicago. This opinion was confirmed by Dr. William J. Wayne of the Indiana Geological Survey, who described the shells as being too recent to be from Lake Chicago and typical of shells found along rivers and swamps. A gray-blue till lies below the shell zone.

Near Hobart and in adjacent parts of Porter County there are deposits of lake clays (pl. 2). These clays were probably laid down in a bay that originally was part of Lake Chicago during the Glenwood stage.

Lake deposits 12 feet thick are exposed in the abandoned clay pit at the Hobart Brick Plant, SW¼ sec. 29, T. 36 N., R. 7 W. The upper 8 feet of the deposit contains layers of laminated, silty, maroon clay separated by thin partings of tan silt. Calcareous concretions are found in horizontal layers and in vertical cracks in this clay 4 to 8 feet below the surface. The layers of maroon clay below this depth are about 0.2 feet or 3.6 inches thick and are separated by thin partings of tan silt or very fine sand. The layers are varve-like and probably represent cylic deposition. These lake deposits are reported to be about 50 feet thick and are described by Blatchley (1897) and Cressey (1928).

Valparaiso Moraine

The massive end moraine that rises abruptly above the Calumet lake plain on the north and the Kankakee glacio-fluvial plain on the south receives its name from Valparaiso in Porter County. The Valparaiso moraine, which rises about 210 feet above Lake Michigan, was built by deposition during the Woodfordian substage of the Wisconsinan ice age and by accumulations from former ice sheets that previously advanced and receded over the area. Contours on the bedrock surface (pl. 3) show that the topographic expression of the Valparaiso moraine is not related to the configuration of the bedrock surface.

Surface Features

Surface features of the Valparaiso moraine in Lake County can be divided into two distinct groups. In the southern section the topography is generally more rugged and typical of morainic areas. The most impressive features of this section of the moraine are the elongated depressions between morainal highs which probably acted as drainageways (spillways) for glacial melt waters flowing toward the Kankakee River. Numerous tributary depressions, formerly streams, now stand high and dry above the main spillways.

Morainic features in the northern section are generally subdued. Knoll-and-kettle type topography, common in morainic areas, is usually absent. A large part of the moraine in this section is relatively flat to undulating.

No evidence of sand and gravel deposits, such as, eskers, kames, or kame terraces were seen on the surface of the moraine in Lake County. East of the county, in Porter County, the moraine becomes more rugged and the till contains more sand, pebbles, cobbles and boulders. This difference in the composition of the till is very noticeable in the road cuts and in the plowed fields. Piles of cobbles and boulders are seen in the fields and along the fence lines in Porter County, but seldom observed in Lake County. Stratified sand and gravel deposits were also observed in Porter County.

All the till observed in Lake County has a very high clay content and a paucity of pebbles, cobbles, and boulders. The best example of the lack of pebbles, cobbles, and boulders is at a pit north of Highland where 55 feet of till is exposed. Pebbles are found throughout the till but no cobbles or boulders were seen. There maybe cobbles and boulders at the base of the pit; covered by water.

Fragments of igneous and metamorphic rocks are conspicuous but less common than shale and limestone. This is understandable since glaciers carry very little rock material far beyond the place where it is picked up. Source of the igneous and metamorphic rock is far to the north in Canada.

The route of the advancing ice was through the elongated trough of Lake Michigan. Much less sandstone was traversed by the ice sheet then shale or limestone, hence the relative small quantities of sand in the till.

The relative flat to undulating surface of the northern section of the moraine is designated as an ablation moraine on the surface geologic map (pl. 2). The till is thought to have accumulated chiefly by lodgment beneath the ice and partly by being let down from the upper surface of the ice through the ablation process. Apparently, the material transported by the ice into Lake County carried an inadequate amount of sand and gravel to be reworked into stratified deposits. Therefore, the surface of the moraine is not one of knoll and depressions, containing stratified features of collapse material, common to ablation moraine. The drift, because of its high content of clay, readily yielded to solifluction and the relief on the moraine was reduced or nearly eliminated to form an undulating plain.

Thinning occurred as the glacial front retreated from the southern part of the moraine. Shrinkage of the glacier, direct result of thinning, slowed the flow of ice to the glacial borders. The ice in the end zone, because of the topographic high of the moraine, became separated from the main body of ice and stagnated. No deposits of linear features were observed to indicate readvance or pauses in the retreat of the ice.

Throughout the moraine are swamps which remain as evidence of former shallow basins that were filled with water from the melting ice of the stagnant glacier. These shallow lakes were filled or are being filled by aquatic plant decay and mineral matter brought in by slope wash. A level area north and east of Crown Point was the largest of these shallow lakes. The water was drained and the area is now being farmed.

Leverett (1899, p. 345 and 1915, p. 216) reported that the Valparaiso moraine in Lake County consists of three ridges; and since then, all glacial geologic maps have shown three distinct ridges extending through the county. However, topographic maps of Lake County show only two ridges. The highest or main ridge north of Cedar Lake has an elevation between 750 and 780 feet above mean sea level. The Continental Divide follows along this ridge, which trends east-west from Cook to the Porter County line (pl. 2). Streams flowing toward the Kankakee River from the glacial front, breached this ridge in many places. Knolls enclosed by the 750 foot contours (pl. 1) are remnants of the ridge.

The second ridge is an end moraine that has been correlated with the Tinley moraine in Illinois (Bretz, 1939, p. 50). This east-west trending ridge enclosed by the 700 foot contour is north of St. John and varies in width from half a mile to 2 miles (pl. 2). The till of the Tinley moraine is a buff to yellow, silty, clay till with some embedded pebbles and cobbles. There is no apparent distinction between the Tinley till north of St. John and the Valparaiso till cropping out along U.S. Highway 41 at the south edge of the Valparaiso moraine. Bretz (1955, p. 81) stated, "To the eye and hand, the Valparaiso till is indistinguishable from the Tinley".

Morainic Lakes.--Most of the closed depressions that held morainic lakes have been destroyed or are swamps in the final process of destruction. Of the few morainic lakes in the county the largest is Cedar Lake which is more than two miles long and about three-quarters of a mile wide.

Cedar Lake was probably formed by melting of a large mass of stagnant ice. Ridges of glacial drift enclose the lake on three sides and to the north rise 60 feet above lake level. The water once overflowed toward the Kankakee River through an outlet in the southern rim of the lake. Today, a dam at the south end of the lake regulates the lake level and is the outlet to Cedar Creek. Cedar Lake has a small drainage area that is fed by runoff from local precipitation, by effluent flow of ground water to the lake, and by springs. The southern end of the lake is slowly being filled by aquatic vegetation and slope wash.

Fancher Lake at the County fairgrounds southwest of Crown Point is on the crest of the highest morainal ridge in the county. The lake is in a small kettle hole formed by the wasting of a mass of ice that was partly or wholly buried in the drift. This lake is deeper than Cedar Lake and is fed by runoff from local precipitation, effluent seepage of ground water, and from springs.

Subsurface Deposits

The subsurface glacial deposits consists of clayey till, clay, silt, sand and gravel. Deposits in Lake County range in thickness from 50 to more than 200 feet, with an average thickness of about 125 feet.

Clayey Tills.-- The term clayey till is used to group till, silt, and clay under a general heading, as they are seldom differentiated by the driller. Blue, gray-blue, gray, yellow, brown, and red clays are reported in the drillers' well logs.

The yellow, brown, and red clayey tills constitute only the upper part of the moraine and well logs show that they range from a thin veneer to a maximum of 60 feet in thickness. These yellow, brown, and red clayey tills are the deposits of the Valparaiso moraine left by the Wisconsin ice sheet.

The gray-blue clayey till (gray, blue, or gray-blue) represents till laid down by older glacial advances, prior to the deposits of the Valparaiso moraine. The gray-blue till lies below the soil in several parts of the moraine but usually is overlain by the buff to yellow, silty, clay till. The color of the clayey gray-blue till varies with the moisture content and depth. When wet the clays have a blue-black or deep grayish-blue color and when dry the color changes to gray or light gray-blue.

The generalized cross sections (pls. 5, 6, and 7) show the vertical relation, lithology of the unconsolidated deposits, and their relation to bedrock. These sections show that two distinct deposits of clayey till are separated by a layer of sand. Above the sand there are two separate tills; (1) a gray-blue clayey till which ranges in thickness from a thin layer to more than 100 feet, and (2) a capping of this gray-blue till by the yellow clayey till of the Valparaiso moraine. The older, undated, lower till that lies below the sand is a gray-blue clayey till. The writer considers the till to be pre-Wisconsinan, Illinoian (?) in age. This till which lies on bedrock is separated from the younger Valparaiso till by glacial drift which in places is over 150 feet thick. Two exposures of this Illinoian (?) till was observed on the Calumet lake plain north of Highland.

Samples of the gray-blue clayey till observed from the upper and lower deposits are similar in color and texture. The gray-blue clayey tills obtain their color from the blue-black shale of Devonian age. The main source of material for the Valparaiso moraine was the shales of the Lake Michigan basin and from the shales underlying Lake County. The shale being relatively soft was easily broken and worn down to clay and silt size and therefore, accounts for the lack of course material.

In the cross sections (pls. 5, 6, and 7) the term "Undifferentiated drift (mainly gray-blue clayey till)" is used. It is the opinion of the writer that the drift consists mainly of gray-blue clayey till, interbedded with some sand and gravel lenses, and at the surface the drift is probably Valparaiso till, a buff to yellow, silty, clay till

The data, records of wells and test holes, used in the cross sections (pls. 5, 6, and 7) can be obtained from the Preliminary Report: Lake County, Bulletin No. 10 (Rosenshein, 1961).

Well No. 36/7W-19K1 is not given in that report because it could not be accurately located, as the well was destroyed during construction of a new subdivision. The author is of the opinion that the location is exact enough to be used for the cross sections.

The log of this well is given below:

Material	Thickness (feet)	Depth (feet)	Remarks
Quaternary System:			
Recent and Pleistocene Series:			Altitude: 640 feet
Sand, fill	5	5	
Muck	9	14	
Clay, gray	46	60	
Sand, gray	35	95	
Clay, gray, soft	35	130	
Clay, gravely, hard	47	177	
Silurian System:			
Broken rock	25	202	Dolomite or dolomitic limestone

<u>Sand</u> <u>and</u> <u>Gravel</u>.--The cross sections (pls. 5, 6, and 7) show that a sheet-like deposit of sand and gravel lies beneath the Valparaiso moraine. This sheet-like deposit ranges in thickness from less than 3 feet to over 100 feet

and underlies an area of about 250 square miles in Lake County. This sand deposit lies upon a gray-blue clayey till which the writer believes to be pre-Wisconsinan, Illinoian (?) in age. The sheet-like sand deposit was probably deposited during the retreat of the ice sheet which deposited the pre-Wisconsinan till and prior to the advent of the Wisconsinan glaciation. This deposit extends into Porter County on the east, into Illinois on the west, and crops out in the Kankakee glaciofluvial plain.

Other smaller lenses or pockets of sand and gravel are interbedded in the drift or lie on bedrock. Well logs report sand and gravel at different levels. The sand and gravel in the glacial drift is the chief source of ground water.

Well logs may report muddy or dirty sand, indicating a silty or clayey sand. Drillers' information, well records, field examination of rock cuttings of the finished well indicate that the sand and gravel deposits contain very little material coarser than pebbles. If further sample studies verify the lack of coarse material, then the sand must have been sorted from the coarser material and transported some distance before being deposited. The source could be from the northeast.

Kankakee Glaciofluvial Plain

In Lake County an area of about 95 square miles of glaciofluvial plain lies between the Valparaiso moraine and the Kankakee River. In 1882 about 500,000 acres of swamp land remained as evidence of a former lake in the Kankakee Valley, 50,000 acres of which were in Lake County (Blatchley, 1897, p. 56). Much of the former marshland has been reclaimed by extensive draining and is now under cultivation. The sinuous Kankakee River has been straightened and leeves constructed along its bank to control flooding. Within the county all the ditches and creeks that cross the plain empty into Singleton Ditch, a parallel drainageway north of the Kankakee River. This ditch discharges its waters into the Kankakee River near Momence, Illinois.

The valley of the Kankakee River begins in St. Joseph County to the northeast and extends westward to the Des-Plaines River in northeastern Illinois. Bradley (1870) stated that a large body of water which was called "Lake Kankakee" formerly occupied much of the Kankakee drainage basin. Bradley's "Lake Kankakee" occupied about 3,000 square miles of which 2,000 square miles were in Indiana (Barrett, 1916, p. 11). Leverett (1899, p. 338 and 1915, p. 128-130) opposed the theory that this large "Lake Kankakee" ever existed. He contended that only shallow lakes of small extent occupied parts of the Kankakee Valley. Leverett further stated that the lake whose waters once covered the large Kankakee marsh as reported by Blatchley (1897) extended only a short distance beyond the edge of this marsh.

Ekblaw and Athy (1925, p. 418) in their studies of northeastern Illinois agreed with Leverett and refuted the existence of a large lake in the Kankakee Valley. They concluded that the Kankakee Valley was a major drainageway for the melt waters of the Michigan, the Saginaw, and the Erie Lobes of the Wisconsin ice sheet; and that a great torrent of glacial waters, called the "Kankakee torrent" (Ekblaw and Athy, 1925, p. 419) had sufficient volume and velocity to erode a channel to considerable depth in the underlying glacial drift. At Momence, Illinois this torrent removed about 30 feet of till and exposed the bedrock.

Upon further retreat of the ice sheet, new outlets were opened to the north that diverted part of the melt waters entering the Kankakee Valley. Because of the decrease in volume and velocity of the water, the heavily loaded melt-water streams dropped their load and deposited the sand and gravel in the Kankakee Valley.

Ekblaw and Athy (1925) reported that the "Kankakee torrent" is younger than the Minooka moraine in Illinois. The Minooka moraine is older than the Valparaiso moraine (Leighton and Willman, 1953); although, both moraines were deposited during the Woodfordian substage. This would indicate that the sand and gravel deposits in the Kankakee Valley are slightly older or contemporaneous with the deposit of the Valparaiso moraine. However, the subsurface evidence in Indiana disputes, in part, this interpretation.

Lines of cross sections in plate 5 show that the sheet-like deposit of sand and gravel that lies beneath the Valparaiso moraine extends into the Kankakee glaciofluvial plain. J. S. Rosenshein of the U.S. Geological Survey and the writer have observed till overlapping the sand of the Kankakee Valley in the SW¼ sec. 26, T. 33 N., R. 8 W. which would indicate that outwash sand in the Kankakee Valley did not lap upon, but rather extended beneath the till of the Valparaiso moraine. At least two glacial advances followed the deposition of this sand and gravel. Therefore, the writer believes that the sand and gravel beneath the Valparaiso moraine and in the lower part of the Kankakee glaciofluvial plain is pre-Wisconsinan, Illinoian (?) in age. The sand and gravel was probably deposited during the retreat of the ice sheet that deposited the Illinoian (?) till that lies upon bedrock. The small glaciofluvial fans built off the Valparaiso moraine in Lake County and the thin upper veneer of material deposited at the surface are probably the only Woodfordian sands in the Kankakee glaciofluvial plain.

Surface Features

The Kankakee glaciofluvial plain slopes gently toward the Kankakee River. On this slope there are small alluvial fans extending out into the Kankakee Valley from the edge of the Valparaiso moraine and a few scattered sand dunes.

Most of the dunes are small and are located between Schneider and Shelby (pl. 2). Because much of the area was marshland the sands were protected from wind erosion and only small dunes were built. The soil of the marshland is a dark sandy loam, very rich in organic matter.

Bog iron in layers ranging in thickness from a thin veneer to about two feet and as concretionary limonitic masses, was observed in several places along drainage ditches. About 1855, bog iron was mined in the county and shipped to the smelter at Mishawaka (Logan, 1922, p. 763).

Subsurface Deposits

The unconsolidated deposits of the Kankakee glaciofluvial plain consist of sand and gravel with an average thickness of about 30 feet. Below the sand and gravel is a gray-blue clayey till which rests on bedrock and locally is more than 50 feet thick. This till is probably of pre-Wisconsinan, Illinoian (?) in age.

The clayey till thins toward the southwest and is missing in the extreme southwestern part of the county. The gray-blue clayey till was deposited upon a gently rolling bedrock surface of dolomitic limestone or dolomite of Silurian age which slopes to the southeast (pl. 3). In the vicinity of Shelby, the till overlies a thin remnant of shale of Devonian age overlying rocks of Silurian age (line B-B', pl. 5).

About 5 feet of water-laid sand and gravel is exposed above the water table in a pit south of Lowell in the SW¼ sec. 1, T. 32 N., R. 9 W. This pit is excavated to a depth of about 35 feet. It is reported that there are some thin layers of blue clay interbedded with sand and gravel. Coarser materials, including cobbles and a few boulders have been removed from the lower part of the pit.

In the NW¼ sec. 8, T. 32 N., R. 8 W. sand and gravel is obtained from below the water table. The owner reported that trees were found in parts of the pit at the water line, about 5 feet below the surface. At a depth of 15 to 20 feet boulders up to 4 feet in diameter were removed from the pit.

Dr. William J. Wayne of the Indiana Geological Survey, (oral communication) reported that, in an abandoned pit in the SW¼NW¼ sec. 5, T. 32 N., R. 5 W., in Porter County, wood was found buried beneath 5 to 6 feet of gravel. A radiocarbon date of 7,900 ± 200 years B.P., determined by the U.S. Geological Survey (W-59) was given for the age of this wood. This suggests that the sand and gravel covering the wood was deposited during the Valderan substage. It does not appear reasonable that the late Wisconsinan deposits should be found in the Kankakee Valley. More radiocarbon dating is needed to establish the age of the upper sands in the Kankakee Valley.

GROUND WATER

Consolidated Deposits

General principles underlying the source, occurrence, and movement of ground water have been described by Meinzer (1923) and others. Ground water in consolidated rocks is stored in the openings, such as joints, fissures, solution cavities and pore spaces. These openings or interstices range in size from very small openings (microscopic) to large openings, such as caverns. The quantity of water that can be obtained from consolidated rocks depends on the size of openings and degree of interconnections.

Deep Rock Aquifers

In Lake County several wells have been drilled into the deep rock aquifers of Cambrian and Ordovician age. The three wells that obtain water from these aquifers have low yields and produce highly mineralized water (table 5). Therefore, the deep rock aquifers are considered to be a poor source of water.

Shallow Rock Aquifers

Niagaran rock of Middle Silurian age is the most productive shallow rock aquifer. A few wells obtain water from the shale of Devonian age. The rocks of Devonian and Silurian age are recharged mainly from the water-bearing sand and gravel in the overlying glacial drift.

Table 5.--Selected chemical analyses of water in Lake County, Indiana. (in parts per million, except, pH. Remarks: I, industry; M, municipalities, public supply; L, Lake Michigan; N, not used as public supply; Rd, deep rock aquifers; Rs, shallow rock aquifers; Sd, sand and gravel).

Location	Well No.	Use	Aquifer	Date of collection	Temperature (°F)	Sillica (SiO_2)	Iron (Fe)	Calcium (Ca)
East Chicago	37/9W-28B1	I	Rd	6-24-54	56	9.6	0.26	213
Gary	36/9W-24C1	I	Rd	6-18-54	65	8.4	1.1	273
Schererville	35/9W-15D1	M	Rs	2-6-58	---	-----	1.2	102
Dyer	35/10W-13C2	M	Rs	4-3-59	---	-----	2.6	105
Lowell	33/9W-23N2	M	Rs	2-6-58	---	-----	.2	12
Schneider	32/9W-34D1	M	Rs	2-6-58	---	-----	.3	66
East Gary	36/7W-16Q2	M	Sd	5-20-59	---	-----	.4	52
New Chicago	36/7W-21C12	M	Sd	9-19-57	---	-----	0	48
Griffith	35/9W-2C1	M	Sd	6-3-54	---	-----	2.4	73
Crown Point	34/8W-5R2	M	Sd	6-18-59	---	-----	3.2	116
Shelby	32/8W-28M2	N	Sd	5-26-56	---	12	7.5	124
Hammond	-----------	M	L	5-20-59	---	-----	0	----
Gary	-----------	M	L	11-2-54	---	2.2	.05	33

a/ U. S. Geological Survey.

b/ Indiana State Board of Health.

c/ Gary-Hobart Water Corp., by Company Chemist.

Table 5.--Continued

Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Total Dissolved solids	Hardness as $CaCO_3$		pH	Remarks
								Calcium and Magnesium	Noncarbonate		
53	392	22	285	402	2.8	0.6	2,003	752	516	7.2	a/
101	774	31	256	1,130	2.4	5.4	3,409	1,098	887	7.7	a/
64	50	6	---	6	.3	---	-----	518	---	7.3	b/
71	46	5	---	6	.4	---	-----	355	---	7.9	b/
8	216	8	---	75	4.4	---	-----	64	---	8.1	b/
29	74	10	---	51	.9	---	-----	284	---	7.5	b/
18	5	2	---	8	0	---	-----	204	---	8.1	b/
15	4	1	---	4	.1	---	-----	184	---	7.8	b/
43	23	2	---	6	.2	---	-----	360	---	7.8	b/
49	15	2	---	14	.1	---	-----	490	---	7.8	b/
42	20	7.6	360	44	0	.1	605	482	187	7.1	a/
---	---	----	---	-----	0	---	-----	130	---	8.2	b/
11	---	----	---	8	.1	.2	-----	131	16	8.2	c/

According to drillers' records the rock of Silurian age underlying the Calumet lake plain is a dense, tight limestone and wells drilled into the rock do not yield large quantities of water. However, sufficient water can generally be obtained locally from this source for domestic use.

South of the Calumet lake plain the rock of Silurian age apparently is more permeable and well yields are higher. Five municipalities; Dyer, Lowell, Schererville, Schneider, and St. John have wells and obtain their water supply from this aquifer. In addition, several industries, many households and farms obtain water from this rock source.

The water from the Silurian and Devonian rock aquifers is usually very hard. The average hardness of water is about 270 ppm, and ranges from 20 to 650 ppm. Selected analyses of water from the shallow rock aquifers are given in table 5. About one-third of the water analyses show more than 0.3 ppm iron which is usually objectionable. "Sulphur" water is common. To avoid "sulphur" water in some localities the domestic wells are drilled only a few feet into the rock. Deeper rock wells in the area always contain "sulphur" water.

Unconsolidated Deposits

Ground water is obtained from the unconsolidated glacial sand and gravel. The quantity of water available from a saturated sand and gravel aquifer depends upon the size and interconnection of the pore spaces.

Recharge

The ground-water reservoir in Lake County is recharged from local precipitation. The sandy areas of the Calumet lake plain and the Kankakee glaciofluvial plain are the most favorable areas of recharge. In the area of the Valparaiso moraine, the soil formed mainly from clayey till impedes the infiltration of water into the ground and recharge is less favorable. However, slow recharge occurs on the moraine, as the surface is flat to moderately rolling, and runoff from precipitation is not rapid.

Discharge and Utilization

Ground-water discharge takes place by natural and artificial means. Under natural conditions ground water is discharged near the surface by evapotranspiration, by seepage and spring flow into streams and lakes, and by migration to distance points of discharge. Ground water is discharged artificially by pumping of water wells and drainage into ditches.

Several thousand acres of land are drained by ditches that lower the ground-water levels and remove excess surface water. The largest drainage project is on the Kankakee glaciofluvial plain where many hundreds of acres of marshland have been reclaimed. Where natural drainage conditions are poor on the Calumet lake plain and on the Valparaiso moraine, the land is drained artificially by ditches.

The slope or hydraulic gradient of the piezometric surface (pl. 8) shows that a ground-water divide coincides closely with the land surface divide. Natural ground-water discharge is toward Lake Michigan on the north and toward the Kankakee River on the south.

Ground water obtained from sand and gravel is the most important source of water for household and farm wells in Lake County. Several municipalities and industries obtain water from the sand and gravel; Crown Point, East Gary, and New Chicago are the largest users. Until recently, Griffith used ground water for its public water supply.

The ground water from the sand and gravel in Lake County is generally harder than that obtained from the shallow rock aquifers. The hardness ranges from about 170 to more than 1,000 ppm.

Most of the water from the sand and gravel contains more than 0.3 ppm iron. The average iron content is about 2.0 ppm and ranges from less than 0.1 to 7.5 ppm. Selected analyses of water from the sand and gravel are given in table 5.

SURFACE WATER

Nearly all the surface water used in Lake County is obtained from Lake Michigan. Because of the nearness to this abundant supply, of lake water, many industries have located on the Calumet lake plain. Besides the large quantities of lake water used by industries, the cities of East Chicago, Gary, Griffith, Hammond, Highland, Hobart, Munster, and Whiting use Lake Michigan as their source of public water supply. The streams, small lakes, and ponds in the county supply some water, mainly for watering stock.

The water from Lake Michigan is softer and contains less iron than the ground water. The hardness of the lake water averages about 130 ppm and the iron content is less than 0.3 ppm. (See table 5.)

SUMMARY

Lake County is in the northwestern corner of Indiana and has an area of about 517 square miles. The county is divided into three physiographic units: the Calumet lake plain, the Valparaiso moraine, and the Kankakee glaciofluvial plain.

The Calumet lake plain was covered by glacial Lake Chicago, and beach lines; the Glenwood, the Calumet, and the Tolleston show phases of the lake's history. Sand dunes cover a large portion of the plain and in the northeast, dunes rise more than 150 feet above the level of Lake Michigan.

The Valparaiso end moraine trends east-west across the county and is about 16 miles wide. The Continental Divide follows along the crest of the moraine. North of this crest is a smaller ridge that is correlated with the Tinley moraine in Illinois.

The Kankakee glaciofluvial plain is about 5 miles wide and has a gentle slope from the Valparaiso moraine to the Kankakee River. This plain, formerly marshland, has been drained and is now under cultivation.

The bedrock surface ranges in elevation from about 625 feet to 450 feet above mean sea level. The general slope of the bedrock surface is from the southwestern part of the county toward the basin of Lake Michigan. Five preglacial stream valleys enter Lake County from a bedrock drainage

divide in Illinois and pass into the basin of Lake Michigan.

A gray-blue clayey till averaging about 50 feet in thickness overlies the bedrock surface and is considered to be pre-Wisconsinan, Illinoian (?) in age. Sand and gravel ranging in thickness from a thin veneer to more than 30 feet, and thin lake deposits overlie this till in the Calumet lake plain. Overlying the till in the remaining part of the county is a sheet-like deposit of sand and gravel that ranges in thickness from less than 3 feet to over 100 feet. This sheet-like deposit, Illinoian (?) in age, lies beneath the Valparaiso moraine and crops out on the surface of the Kankakee glaciofluvial plain. The upper part of the outwash on the Kankakee glaciofluvial plain was probably deposited during the Woodfordian substage.

Two distinct tills were deposited upon this sand and gravel in the area of the Valparaiso moraine. The lower till is a gray-blue clayey till similar in appearance and texture to the gray-blue clayey till lying upon the bedrock. The upper till is a buff to yellow, silty, clay till of the Valparaiso and Tinley moraines which was deposited during the Woodfordian substage.

Ground water is the source of water supply in the Valparaiso moraine and the Kankakee glaciofluvial plain. Sufficient quantities can be obtained to supply small municipalities. The ground water is generally very hard and usually contains an objectionable amount of iron. Deep rock aquifers are a poor source of water because of high mineralization and low yield. Large quantities of good water from Lake Michigan supplies the water for the industries and municipalities of the Calumet lake plain.

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NEWTON CO.

Base from Modified General Highway and Transportation Map revised to July 1953. Drainage and town boundaries in part from U.S. Geological Survey topographic maps.

TOPOGRAPHIC MAP OF LAKE COUNTY, INDIANA

0 1 2 3 MILES

0 5000 10000 15000 FEET

CONTOUR INTERVAL 50 FEET

DATUM IS MEAN SEA LEVEL

BY R.J. VIG

1962

PLATE 2

SURFACE GEOLOGY OF LAKE COUNTY, INDIANA

BY R. J. VIG

1962

EXPLANATION

——— 600 — — —

Contour showing altitude of bedrock surface, dashed where approximate

Contour interval 25 feet

Datum is mean sea level

Base from Modified General Highway and Transportation Map revised to July 1953. Drainage and town boundaries in part from U.S. Geological Survey topographic maps.

Map compiled from subsurface geologic data obtained from driller's logs of wells and from seismic data obtained from the Indiana Department of Conservation, Geological Survey.

MAP OF LAKE COUNTY, INDIANA SHOWING CONTOURS ON THE BEDROCK SURFACE

0 1 2 3 MILES
0 5000 10000 15000 FEET

BY R.J. VIG
1962

EXPLANATION

Well or test boring penetrating bedrock, used in cross sections on plates 5, 6, and 7

Well or test boring in unconsolidated rock, used in cross sections on plates 5, 6, and 7

Well or test boring in unconsolidated rock

Well or test boring penetrating bedrock

Seismic determination of bedrock

A ——— A'

Line of cross sections shown on plates 5, 6, and 7

Base from Modified General Highway and Transportation Map revised to July 1953. Drainage and town boundaries in part from U.S. Geological Survey topographic maps.

Seismic data obtained from the Indiana Department of Conservation, Geological Survey.

MAP OF LAKE COUNTY, INDIANA SHOWING LOCATIONS OF WELLS AND LINES OF GEOLOGIC SECTIONS

0 1 2 3 MILES

0 5000 10000 15000 FEET

BY R.J. VIG

1962

PLATE 4

PLATE 5

SECTIONS SHOWING GENERALIZED GEOLOGY

LINES A-A' TO C-C'

0 1 2 3 MILES
0 5000 10000 15000 FEET

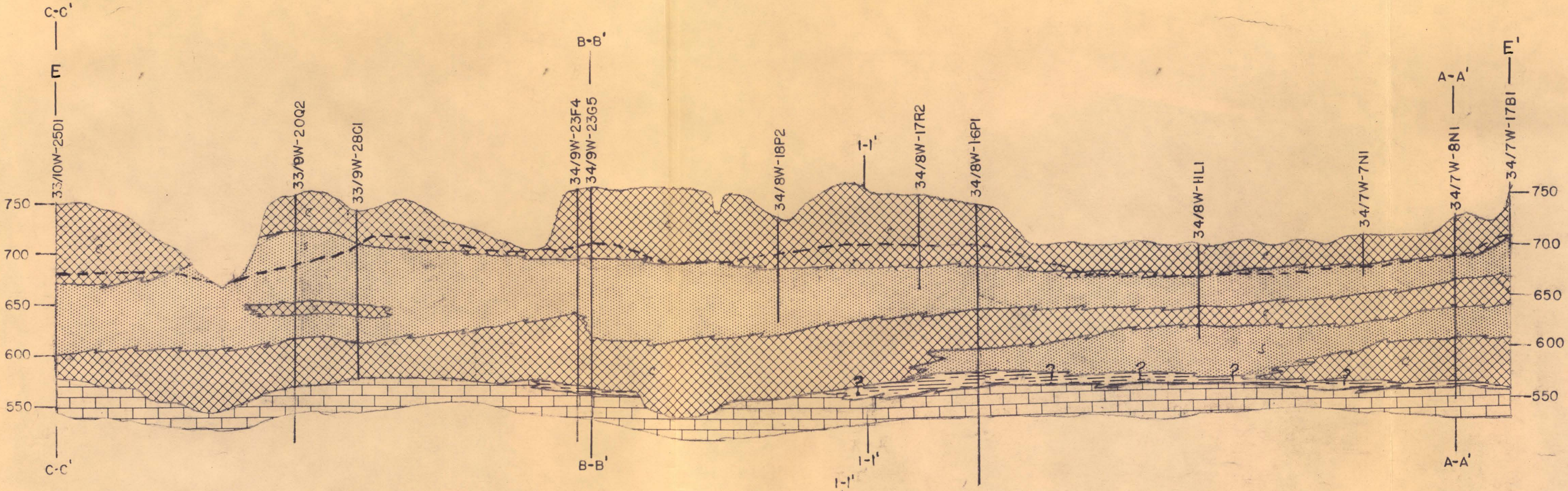
VERTICAL EXAGGERATION 50 TIMES

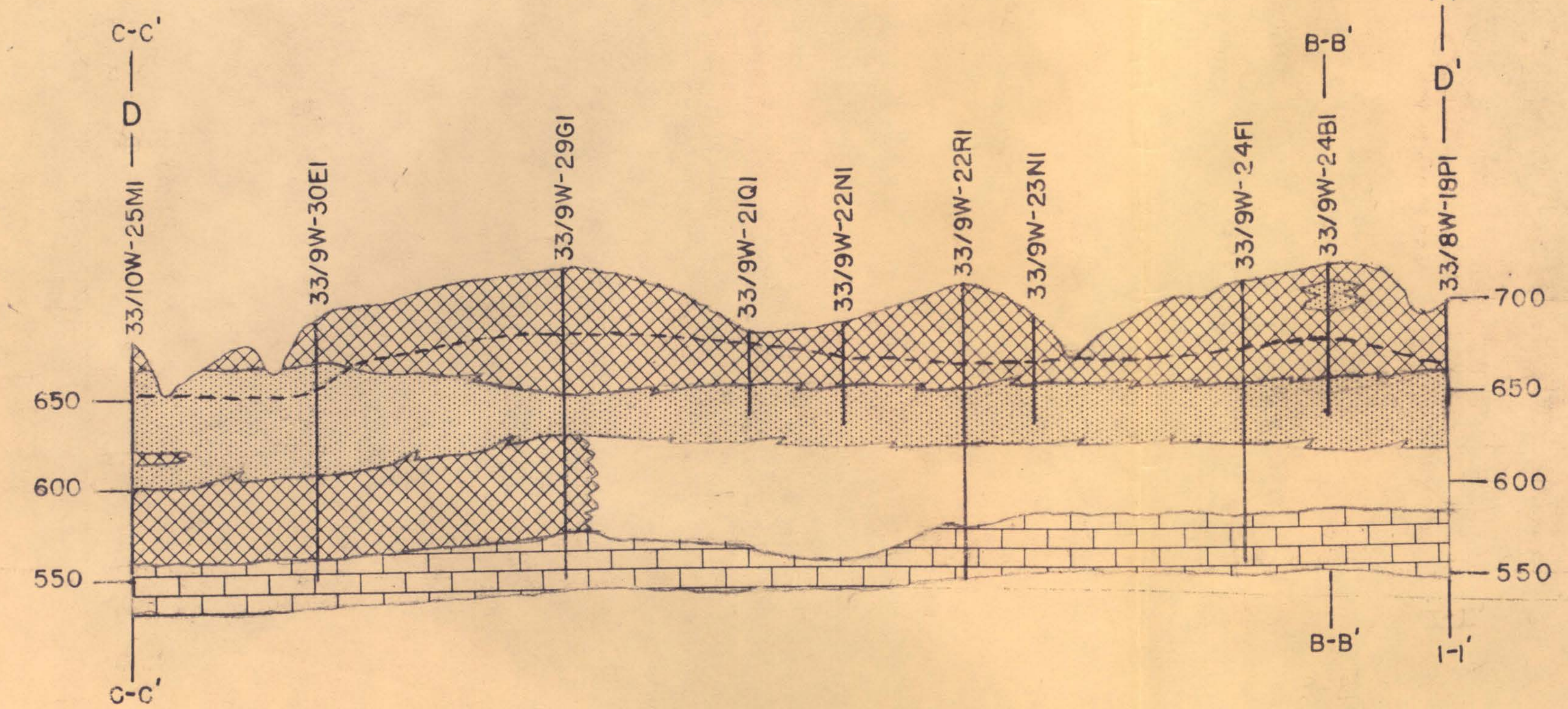
DATUM IS MEAN SEA LEVEL

BY R.J. VIG

1962

PLATE 6





SECTIONS SHOWING GENERALIZED GEOLOGY

LINES D-D' TO E-E'

0 1 2 3 MILES

0 5000 10000 15000 FEET

VERTICAL EXAGGERATION 50 TIMES

DATUM IS MEAN SEA LEVEL

BY R.J. VIG

1962

EXPLANATION

Sand and gravel

Clayey till

Undifferentiated drift (Mainly gray-blue clayey till)

Shale

Dolomitic limestone or dolomite

Water surface

Altitude of bedrock surface queried where approximate

For location of sections see plate 4

PLATE 7

SECTIONS SHOWING GENERALIZED GEOLOGY

LINES F-F' TO J-J'

0 1 2 3 MILES

0 5000 10000 15000 FEET

VERTICAL EXAGGERATION 50 TIMES

DATUM IS MEAN SEA LEVEL

BY R. J. VIG

962

EXPLANATION

——700—— – –

Contour showing altitude of piezometric surface; dashed where approximate

Contour interval 25 feet

Datum is mean sea level

Base from Modified General Highway and Transportation Map revised to July 1953. Drainage and town boundaries in part from U.S. Geological Survey topographic maps.

MAP OF LAKE COUNTY, INDIANA SHOWING GENERALIZED CONTOURS OF THE PIEZOMETRIC SURFACE

PLATE 8

0 1 2 3 MILES

0 5000 10000 15000 FEET

BY R. J. VIG

1962